

Article Title: The CelluTome epidermal graft harvesting system: A patient reported outcome measure and cost evaluation study

Authors: Oliver J Smith MBChB, SJ Edmondson MRCS, Nicki Bystrzonowski MRCS, Nadine Hachach-Haram MRCS, Muholan Kanapathy MRCS, Toby Richards FRCS, Ash Mosahebi FRCS (Plast)

Affiliation and institute of study: Department of Plastic Surgery, Royal Free Hospital, Pond Street, London, UK, NW3 2QG

Corresponding author: Mr Ash Mosahebi, Department of Plastic Surgery, Royal Free Hospital, Pond Street, London, UK, NW3 2QG. ashmosahebi@gmail.com

Abstract

Introduction

Conventional split skin grafts (SSG) require anaesthesia, specialist equipment and can have high donor site (DS) morbidity. The CelluTome epidermal-graft-harvesting-device is a novel alternative, providing pain-free epidermal skin grafts (ESG) in the outpatient setting with projected minimal DS trauma and improved patient satisfaction. This study aimed to compare ESG with SSG by evaluating patient related outcome measures (PROMs) and cost implications of both.

Methods

Twenty patients answered a graft satisfaction questionnaire which evaluated: donor/graft site noticeability, aesthetic concerns, adverse problems and patient satisfaction. Cost/patient was calculated based on total operative expenses and five clinic followups.

Results

In 100% of ESG cases there were no DS noticeability or adverse problems compared to 25% in the SSG group. Complete satisfaction with DS appearance was observed in 100% of ESG cases

(50% SSG). Noticeability, adverse problems and overall satisfaction were significantly better in ESG ($p < 0.05$). Graft site parameters were comparable with similar healing outcomes.

The cost per patient for ESG was £431 and £1489 for SSG with an annual saving of £126960 based on ten grafts/month.

Conclusion

For the right patient, CelluTome provides comparable wound healing with reduced DS morbidity and higher patient satisfaction.

Key Words

CelluTome; Cost analysis; Epidermal skin grafting; Patient recorded outcome measures; Split skin grafting

Key Messages

- **Epidermal skin grafting with the CelluTome device may provide better donor site results and have improved patient satisfaction compared to conventional split skin grafting**
- **The aim of the study was to evaluate patient recorded outcome measures and cost implications of epidermal and split skin grafts through the use of questionnaires**
- **Epidermal graft donor sites had significantly better noticeability scores with significantly fewer adverse outcomes and better patient satisfaction. Graft site satisfaction and healing outcomes were similar in both groups. There was a saving of £1058 per patient when using epidermal grafting compared to split skin grafting.**

Reviewers:

Pari Mohanna

Text

Introduction

CelluTome (Acelity, USA) is a novel device which harvests the epidermal layer of the skin through suction blister formation providing autologous keratinocytes for grafting (1). It acts through a combination of the application of heat (up to 40 degrees) and a negative pressure (400-500mmHg) to provide epidermal skin grafts (ESG) in an out-patient setting, which cause minimal or no pain with reduced donor site (DS) trauma and without the need for anaesthesia: leading to improved patient satisfaction compared with other skin grafting procedures. The device carries a one-off cost of approximately £7500.

The technique of suction blistering of the epidermis was first described in 1964 by Kiistala and Mustakallio (2). Their technique proposed complete detachment of the epidermis from dermis at the dermo-epidermal junction with the application of negative pressure (150 – 200mmHg), with minimal intra-operative trauma. However, it was not until 1971, that Falabella (3) first described the use of this technique to provide an ESG, showing that ESG was a valuable tool for providing coverage of granulating areas and repigmentation of achromic lesions. Falabella's work opened up the possibility of using this technique to cover various different types of granulating wounds and has, since then, been used widely by dermatologists in the treatment of Vitiligo. Despite this, the use of ESG in the management of non-healing chronic wounds or acute wounds with poor tissue coverage, to-date has been minimally explored.

Wound management costs the NHS an estimated £2.3 – 3.1 billion per annum (4). The majority of wounds are managed in the outpatient setting with protocols that vary according to geography, in-

stitution and speciality: despite this, split skin grafts (SSG) remain the standard treatment for definitive wound closure for wounds with granulating bed. Split skin grafts require a dedicated room or theatre with the correct equipment, anaesthesia (whether local, regional or general), a period of immobility for some patients, occasionally hospital admission and are associated with high DS morbidity, requiring attentive DS wound care and pain management. Cellutome provides similar wound cover with minimal or pain-free epidermal skin grafts in an outpatient setting, without the need for anaesthesia or additional instruments.

Our study aims to evaluate the patient reported outcome and cost efficiency of using CelluTome to provide ESG in an outpatient setting against SSG. Evidence has shown that the systematic use of information from patient recorded outcome measures (PROMs) leads to overall better decision making between doctors and patients and results in patients being more satisfied with their treatment [5]. By comparing PROMs and the cost of ESG versus SSG in an analogous cohort of patients, we aim to determine if CelluTome is a viable alternative to current wound management technique besides being cost effective for the NHS and patient.

Methods

Patient Reported Outcome Measures (PROMs)

Twenty demographically matched patients (ten who had undergone SSG and ten who had undergone ESG with CelluTome) were selected for inclusion in the study (**Table 1**). All patients received grafting once wounds showed healthy granulation tissue with good vascularity. PROMs were assessed using a validated patient skin graft satisfaction questionnaire (**Appendix 1**). All patients received the questionnaire at least six weeks after their procedure. The questionnaire assessed patient views on donor and graft site, noticeability; problems; concerns about cosmetic appearance; and, overall outcome. The results were found to be non-normally distributed using Shapiro-Wilk normality test and were analysed using the Mann-Whitney U test.

Patients also underwent weekly wound assessment in dressings clinic to monitor progress of healing.

Cost Analysis

A calculation was made for expenditure and income for inpatient split skin grafting, a CelluTome procedure and conservative dressing management. The cost of each patient event was calculated using the corresponding OPSC codes and overall cost of each treatment event was calculated as an average of the patients included in this study taking into account co-morbidities.

For both the SSG and CelluTome procedures costing included one initial and four follow-up dressing clinic appointments, the average standard practice in our department. For conservative dressing management, costing included one initial and fourteen follow-up dressing clinic appointments.

An annual cost was also calculated based on an estimate of ten patients per month, which is the expected case volume once the service is fully operational.

Results

Patient Recorded Outcome Measures

Donor site:

There was no DS noticeability, adverse problems or concerns in 100% of patients undergoing ESG. All patients were either very (80%) or somewhat (20%) satisfied with their donor site outcome. All donor sites healed fully with an average healing time of 5 days.

In comparison, only two patients in the SSG group stated that they did not find their donor site noticeable with six patients finding it either somewhat or very noticeable. Six of the SSG patients found their donor site to be problematic to some degree. Four patients were unsatisfied to some degree with the overall outcome. However, only two patients were concerned about their donor site appearance. All donor sites healed fully.

DS noticeability, adverse problems and overall satisfaction were statistically significantly better in ESG ($p < 0.05$).). **Table 2** shows a summary of all the results regarding the donor site in the ESG and SSG groups respectively.

Graft recipient site:

Overall, 80% of ESG patients were completely satisfied with the appearance of their graft site. Only 30% of patients found their graft site very noticeable, whilst 10% found it not noticeable at all. 40% of patients had no concerns or adverse problems with their graft site. Those that complained of it being problematic were referring to the length of time it took for the graft to heal, but none complained about pain or infection.

Eight ESG patients had evidence of healing at the graft site, with two having a 50% reduction in wound size and six having a 100% reduction. Average healing time for 100% reduction was six weeks. Two patients had failed grafts.

The graft site in SSG was noticeable to some degree in all patients, with 70% of patients finding it very or somewhat noticeable. Despite this the majority of patients (70%) were not concerned at all about their graft site appearance, with only two patients suffering adverse problems. Overall satisfaction rates showed 100% of people were satisfied to some degree. The results of the statistical analysis for the CelluTome and SSG graft sites are summarised in **Table 3**. There was no statistically significant difference in the outcomes of the two groups.

Four SSG patients had 100% reduction in wound size, with the other six having at least 50% reduction. Average healing time for 100% reduction was 9 weeks. There were no graft failures. One patient suffered a graft site infection requiring a course of antibiotics. Two patients expressed dissatisfaction at long healing times. A comparison of ESG and SSG graft site healing is shown in **Table 4**.

Cost Analysis

The average individual cost and income per patient event are summarised in **Table 5**. The overall loss/profit per treatment option (including dressing clinic followup) for individual patients and annually are summarised in **Table 6**. The comparisons between overall individual cost per treatment option is illustrated in **Figure 1**.

Discussion

Management of acute and chronic wounds costs the NHS billions of pounds per annum and has been identified by the WHO as a significant health problem (6). Current management options include split skin grafting or conservative management. However, SSG often requires anaesthesia in a setting with access to the correct equipment, and can cause significant donor site morbidity and discomfort for the patient. Conservative dressing management is often an extremely long process requiring many attendances by nurses (either in the community or in a hospital dressing clinic) with varying outcomes and occasional progression to theatre for a SSG or commencement of negative pressure wound therapy.

Epidermal graft harvesting has previously been shown to be effective in the management of lower limb wounds (7-10). Recent case series have also shown that the CelluTome epidermal graft harvesting device is effective in managing a variety of acute and chronic wounds in a wide range of patients, offering a viable alternative to SSG (11-13).

Our study is the first to evaluate patient related outcome measures in patients treated with the CelluTome device. Currently there is a growing need for transparency in results and procedural outcomes from both operator and patient's perspective. Chronic non healing wounds often cause stress and morbidity to patients. Treatment options that do not involve anaesthesia, donor site morbidity and an admission to hospital (whether as a day case or longer stay) should be widely

available. PROMs have been used to monitor outcomes for certain procedures in the surgical community for several years now. They have been widely shown to improve public transparency, aid surgeons to improve their practice, to offer patients informed choices about their care, whilst aiding health service commissioners to make sensible funding decisions (14). Subjective rating scale questionnaires such as the one used in this study are validated tools for assessment of psychological impact of skin grafting and provide a review of a patient's opinion on a specific treatment (15).

We found that 100% of patients had no concerns, adverse outcomes or issues with noticeability of their donor site, with all patients being either somewhat or very satisfied with the final outcome and all donor sites showing complete healing. This is in comparison with SSG patients, of which three-quarters found their donor site to be significantly more noticeable, half of whom experienced problems such as on-going pain, requiring analgesia and the donor taking longer than expected to heal, and only half being satisfied with the final outcome. PROM categories for noticeability, adverse problems and overall satisfaction were statistically significantly better in the CelluTome cohort. Cellutome patients have reduced discomfort, with previous studies also illustrating rapid healing of the donor site within a few days (11,12).

There was no statistically significant difference between CelluTome and SSG patients when patients were asked about their opinion of their graft site. Furthermore, 80% of CelluTome patients were completely satisfied with the graft site outcome and the majority of patients showed good evidence of healing at the graft site. These findings illustrate that patient perception of wound site healing with CelluTome grafts is satisfactory and similar to current standard therapy. The difference in patient perceptions of adverse outcomes of the graft site was approaching significance with SSG showing improved results. However this was related to issues with time to healing rather than complications and previous studies have shown excellent results with wound site healing when using CelluTome. In a small case series of patients with Pyoderma Gangrenosum the authors found a significant reduction in wound size in all patients, with 60% of patients experiencing complete wound closure (12). Another study found a decrease in wound size in six out of seven

patients despite numerous patient comorbidities (11). However, larger studies are required to evaluate the effectiveness of CelluTome derived ESG in wound healing compared to SSG and a randomised controlled trial comparing the two options in the future is essential.

Our study also found that the average cost of using the CelluTome device was considerably less than both SSG and conservative dressing management per individual patient. An annual estimate based on twenty CelluTome patients per month shows a significant saving compared to traditional treatment options. The calculations are estimates and do not represent actual spending, however they provide an excellent overview of the potential financial benefits of this procedure. A particular benefit of CelluTome is its ease of use in an outpatient setting which is cost effective and more importantly convenient for patients. Serena et al (2015) have also highlighted that the cost and simplicity of the device make it an excellent option for resource-poor nations (11), as well as developed regions under contemporary austerity pressures.

A limitation of the cost analysis is that the ultimate cost of each treatment event was based on an average of the patients in this study which takes into account the OPSC code plus each patients co-morbidities. Therefore ultimate revenue of each procedure will be variable as an HRG code will be calculated for each patient based on the treatments given and co-morbidities. It must also be highlighted that the costing in this article is based on UK coding procedures and therefore costing will vary in other healthcare systems based on different coding practices.

The small sample size is the main limitation of this study, which makes statistically based conclusions more difficult. However given this is a new experimental procedure there is not yet a large patient population from which to draw data and further studies are required to provide more evidence.

Conclusion

Epidermal skin grafting using a CelluTome epidermal graft-harvesting device is associated with a significant improved patient perceived donor site outcomes when compared to SSG. This com-

combined with the possible financial benefits and comparable graft site outcomes means ESG should be considered as a first line treatment option for both small chronic and acute wounds requiring skin coverage in the right patient.

Acknowledgements

None

Conflict of Interest

None

References

- 1) <http://www.kci1.com/KCI1/cellutome>
- 2) Kiistala U, Mustakallio KK. In-vivo separation of epidermis by production of suction blisters. Lancet. 1964; 1:1444 -1445.
- 3) Falabeela R. Epidermal Grafting. An original technique and its application in achromic and granulating areas. Archives Derm. 1971; 104(6): 592 – 600.
- 4) Posnett J, Franks PJ. The burden of chronic wounds in the UK. Nursing Times. 2008; 104 (3): 44 – 45.

- 5) Nelson EC, Eftimovska E, Lind C et al. Patient reported outcome measures in practice. BMJ. 2015;10:350:g7818
- 6) World Health Organization. Noncommunicable Diseases Country Profiles 2014. Geneva, Switzerland: World Health Organization; 2014.
- 7) Costanzo U, Streit M, Braathen LR. Autologous suction blister grafting for chronic leg ulcers. J Eur Acad Dermatol Venereol. 2008;22(1):7-10
- 8) Yamaguchi Y, Sumikawa Y, Yoshida S et al. Prevention of amputation caused by rheumatic diseases following a novel therapy of exposing bone marrow, occlusive dressing and subsequent epidermal grafting. Br J Dermatol. 2005;152(4):664-72
- 9) Yamaguchi Y, Yoshida S, Sumikawa Y et al. Rapid healing of intractable diabetic foot ulcers with exposed bones following a novel therapy of exposing bone marrow cells and then grafting epidermal sheets. Br J Dermatol. 2004;151:1019-28
- 10) Hentzer G, Kobayasi T. Suction blister transplantation for leg ulcers. Acta Derm Venereol. 1975;55(3):207-9
- 11) Serena T, Francius A, Taylor C et al. Use of novel epidermal harvesting system in resource-poor countries. Adv Skin Wound Care. 2015;28(3):107-12
- 12) Richmond NA, Lamel SA, Braun LR et al. Epidermal grafting using a novel suction blister-harvesting system for the treatment of pyoderma gangrenosum. JAMA Dermatol. 2014;150(9):999-1000
- 13) Hachach-Haram N, Bystrzonowski N, Kanapathy M et al. The use of epidermal grafting for the management of acute wounds in the outpatient setting. J Plast Reconstr Aesthet Surg. 2015;68(9):1317-8
- 14) Monthly patient reported outcome measures (PROMS) in England A guide to PROMS methodology. Health and Social Care Information Centre. 2015.

http://www.hscic.gov.uk/media/1537/A-Guide-to-PROMs-Methodology/pdf/PROMs_Guide_V10.pdf

- 15) Hansen EL, Clarke A, Austin-Parsons N et al. The psychological impact of split-thickness skin grafts. J Wound Care. 2012;21(10):490-2, 494-7

Tables

	CelluTome Patients (n=10)	Split skin graft patients (n=10)
Age: Average (range)	74 (50-93)	54.6 (19-94)
Male:Female	3:7	6:4

Aetiology of wound		
Chronic traumatic wound	5	7
Acute wound	3	3
Venous ulcer	2	0
Location of wound		
Leg	9	10
Abdomen	1	0
Average wound size (mean cm²)	16.5	21

Table 1: Demographics of patients included in the study

	Noticeability		Concerns		Adverse Problems		Overall Satisfaction	
	<i>Cellutome</i>	<i>Ssg</i>	<i>Cellutome</i>	<i>Ssg</i>	<i>Cellutome</i>	<i>Ssg</i>	<i>Cellutome</i>	<i>Ssg</i>
Mean	1.0	3.3	1.0	1.8	1.0	2.2	1.2	2.7
Standard Deviation	0.00	1.64	0.00	1.23	0.00	1.23	0.42	1.64
P value	<0.01*		0.14		0.025*		0.03*	

Table 2: Summary of results of PROM for Donor Sites with P-Values from 1-Tailed Students T Test. Statistically significant results are highlighted by *

	Noticeability		Concerns		Adverse Problems		Overall Satisfaction	
	<i>Cellutome</i>	<i>SSG</i>	<i>Cellutome</i>	<i>SSG</i>	<i>Cellutome</i>	<i>SSG</i>	<i>Cellutome</i>	<i>SSG</i>
Mean	3.6	3.9	2.4	2.2	2.4	1.3	2.4	1.8
Standard Deviation	1.43	1.10	1.43	1.62	1.65	0.48	0.97	0.63
P value	0.3		0.47		0.12		0.096	

Table 3: Summary of results of PROM for Graft Sites with p-values from Mann-Whitney U test.

	50% reduction	100% reduction	Failed grafts	Average time to 100% reduction (weeks)
ESG	2	6	2	6
SSG	6	4	0	9

Table 4: Comparison of ESG and SSG graft site healing outcomes

Patient Event	OPSC Code	Average Individual Cost (£)	Average income per event (£)	Loss/profit per event

Inpatient SSG	S35.2	1060	1032	-28
CelluTome	S36.8	349	668	319
Initial dressing clinic appointment	S57.4	91	137	46
Followup dressing clinic appointment	S57.5	84	79	-5

Table 5: Summary of average cost and income per patient event

Treatment Option	Expenditure per patient (£)	Loss/profit per patient (£)	Overall cost per patient (£)	Annual expenditure for 120 patients (£)	Annual loss/profit for 120 patients (£)	Overall annual cost for 120 patients (£)
SSG + dressing clinic followup	1487	-2	1489	178440	-240	178680
CelluTome + dressing clinic followup	776	345	431	93120	41400	51720
Dressing management only	1267	-24	1291	152040	-2880	154920

Table 6: Summary of overall loss/profit per treatment option for individual patients and annually

Figure Legends

Figure 1: Graph illustrating overall individual costs per treatment option

Appendix 1

1. How noticeable do you find your donor site?

Very noticeable - 5	Somewhat noticeable - 4	Slightly noticeable - 3	No particular feeling - 2	Not noticeable - 1

2. Are you concerned about your donor site appearance?

I worry very much - 5	I worry somewhat - 4	I worry a little - 3	No particular feeling - 2	I do not worry - 1

3. Did you suffer any problems with your donor site?

Very problematic - 5	Somewhat problematic - 4	Slightly problematic - 3	No particular feeling - 2	Not problematic - 1

4. Overall how would you rate the outcome of your donor site?

Very unsatisfied - 6	Somewhat unsatisfied - 5	Slightly unsatisfied - 4	Slightly satisfied - 3	Somewhat satisfied - 2	Very satisfied - 1

5. How noticeable do you find your graft site?

Very noticeable - 5	Somewhat noticeable - 4	Slightly noticeable - 3	No particular feeling - 2	Not noticeable - 1

6. Are you concerned about your graft site appearance?

I worry very much - 5	I worry somewhat - 4	I worry a little - 3	No particular feeling - 2	I do not worry - 1

7. Did you suffer any problems with your graft site?

Very problematic - 5	Somewhat problematic - 4	Slightly problematic - 3	No particular feeling - 2	Not problematic - 1

8. Overall how would you rate the outcome of your graft site?

Very unsatisfied - 6	Somewhat unsatisfied - 5	Slightly unsatisfied - 4	Slightly satisfied - 3	Somewhat satisfied - 2	Very satisfied - 1

